SIGGRAPH 2001 Fundamentals Seminar:

Computer Graphics Hardware

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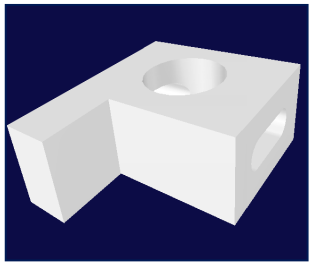
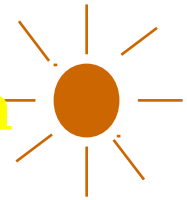
The Generic Graphics Process



Lighting Information



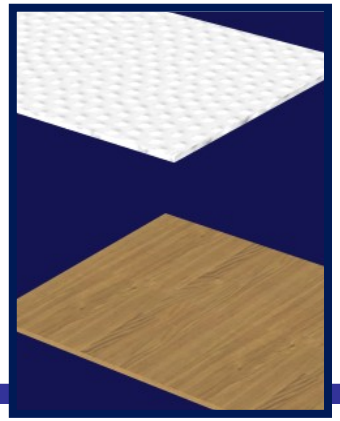
3D Geometric Models

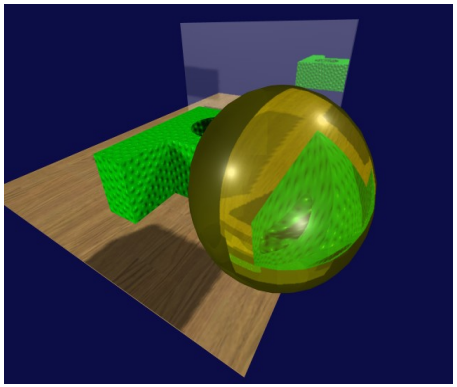
Rendering

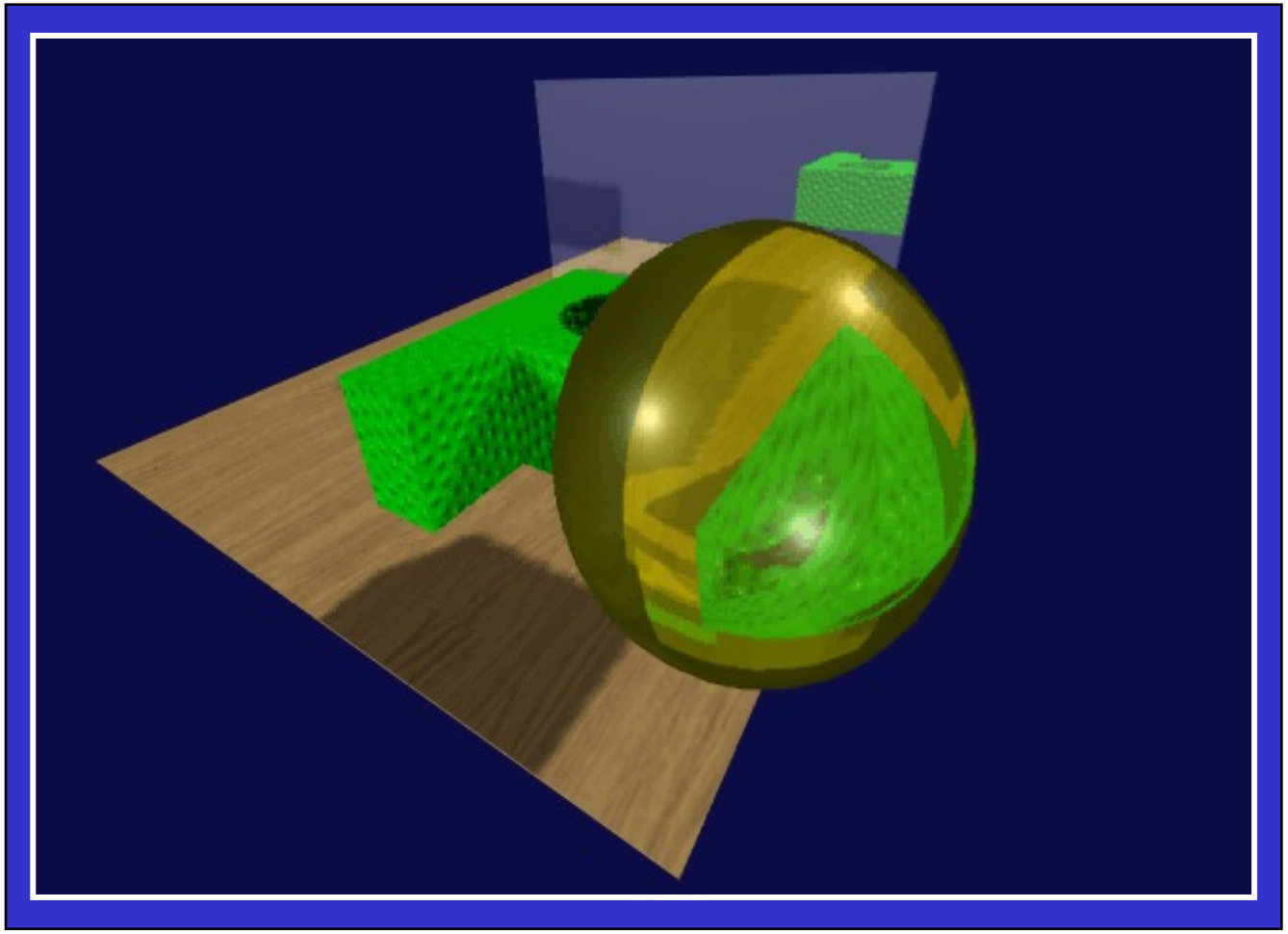
Image Storage and Display

3D Animation Definition

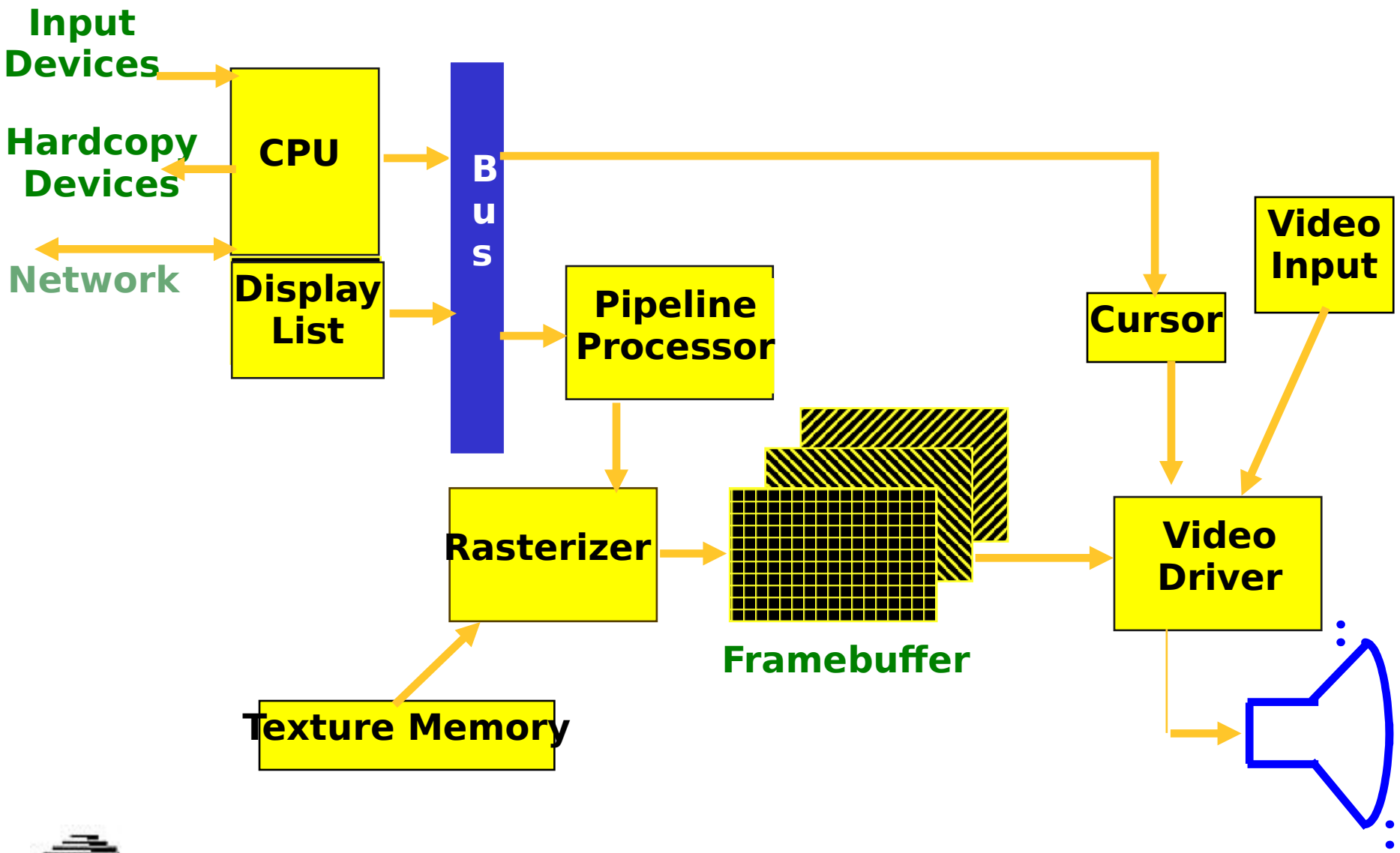
Texture Information



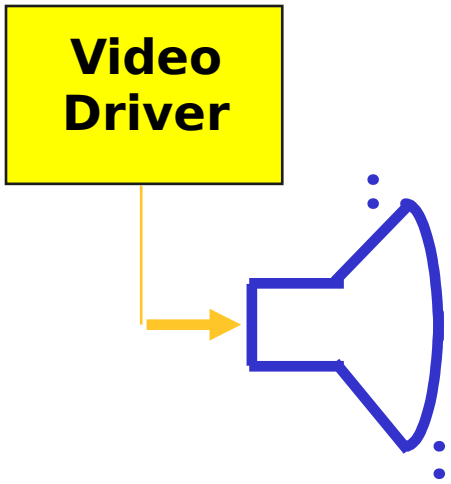




he Generic Computer Graphics Syste

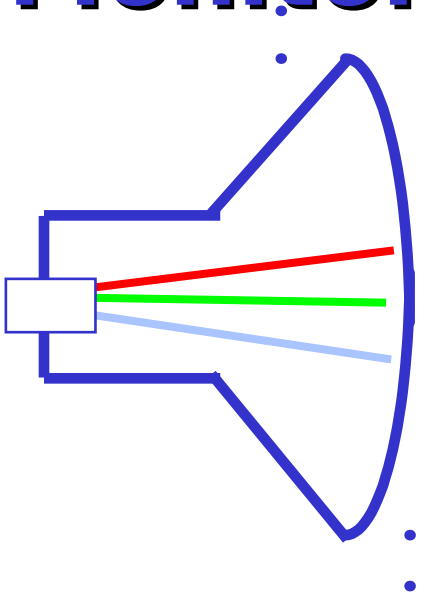


The Computer Graphics Monitor

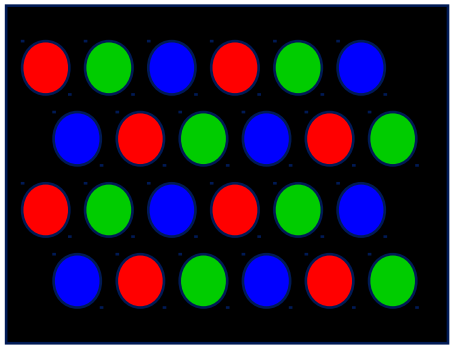


Displaying Color on a Computer Graphics Monitor

- 3 color guns
- Red-green-blue phosphors



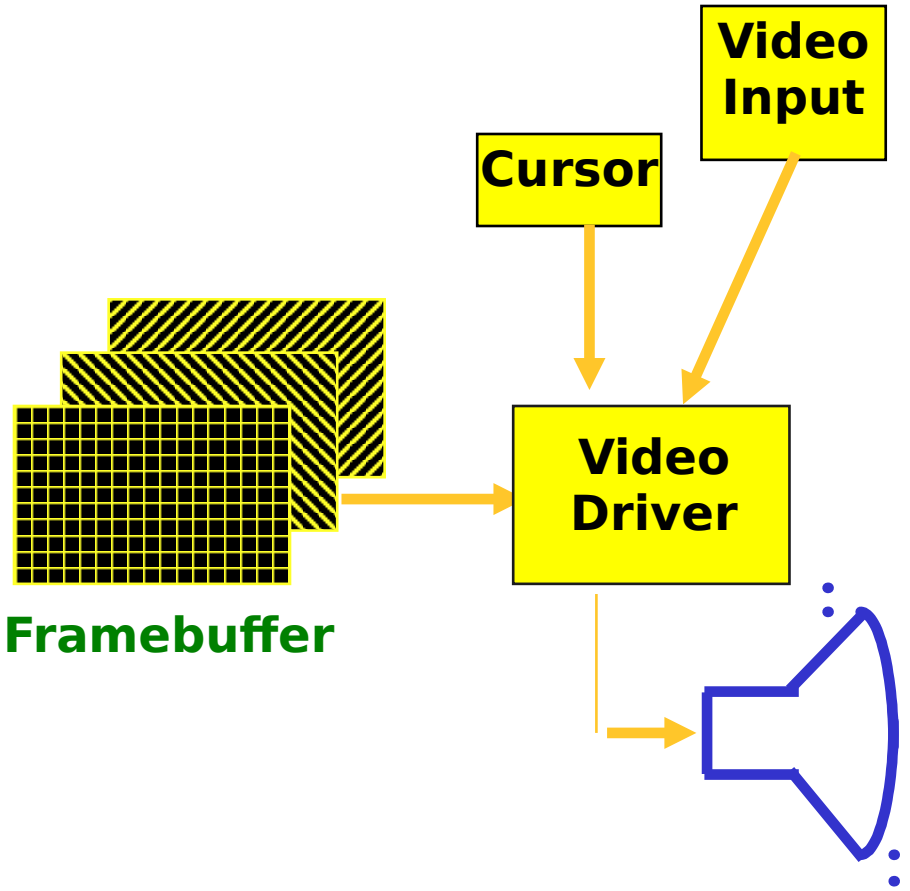
- Gun voltage ≈ color brightness



Display Resolution

- ***Pixel*** **resolutions (640x480 - 1600x1024 are common)**
- **Screen size (13", 16", 19", 21" are common)**
- **Human acuity: 1 arc-minute is achieved by viewing a 19" monitor with 1280x1024 resolution from a distance of ~40 inches**
- **FYI: HDTV is talking about resolutions in the 2048x1152 range**

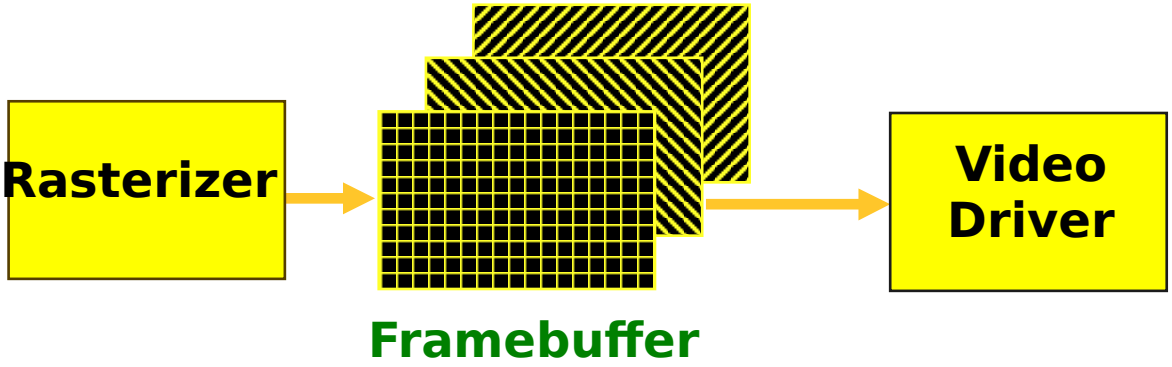
The Video Driver



The Video Driver

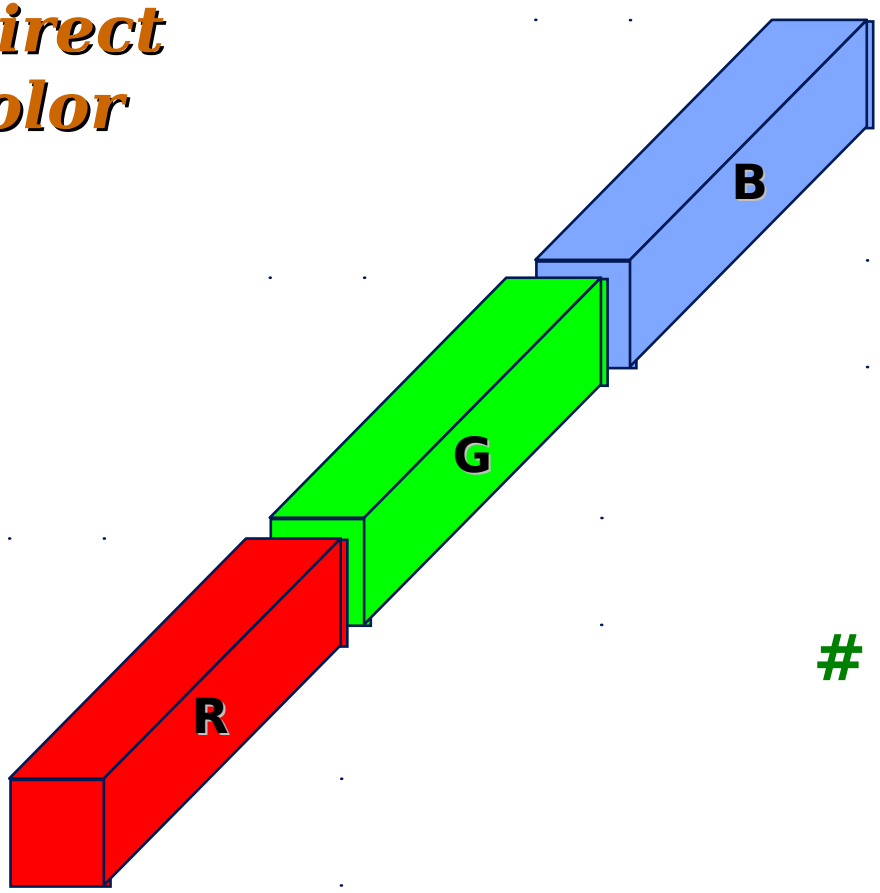
- N *refreshes*/second (N is usually between 40 and 80)
- Framebuffer contains the R,G,B that defines the color at each pixel
- Cursor
  - Appearance is stored near the video driver in a “mini-framebuffer”
  - x,y is given by the CPU
- Video input

The Framebuffer



The Framebuffer

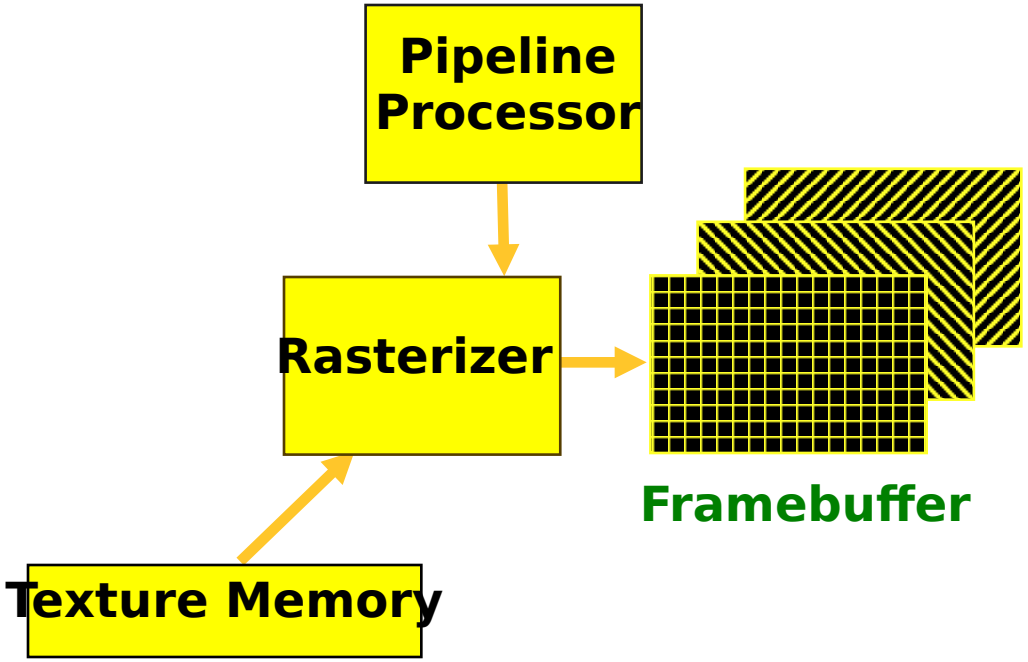
- *Direct color*



# Bits/pixel	Total colors:
12	2^{12} = 4K
18	2^{18} = 256K
24	2^{24} = 16.7M

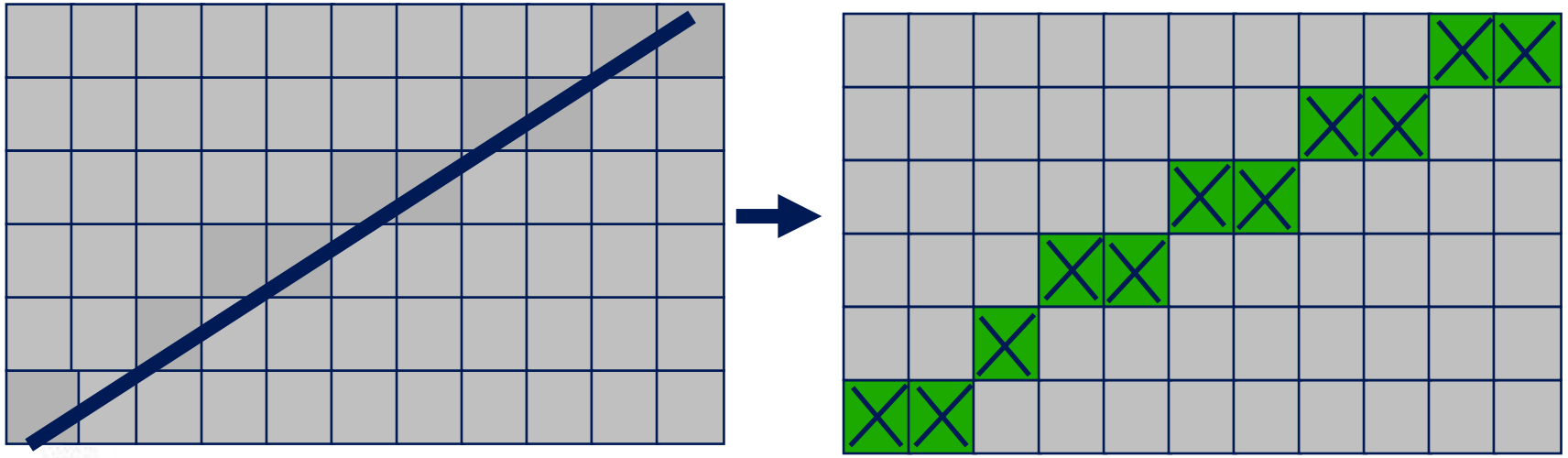
# Bits/color	# Shades per color
4	2^4 = 16
6	2^6 = 64
8	2^8 = 256

The Rasterizer



Rasterization

- Turn screen space vertex coordinates into pixels that make up lines and polygons
- A great place for custom electronics



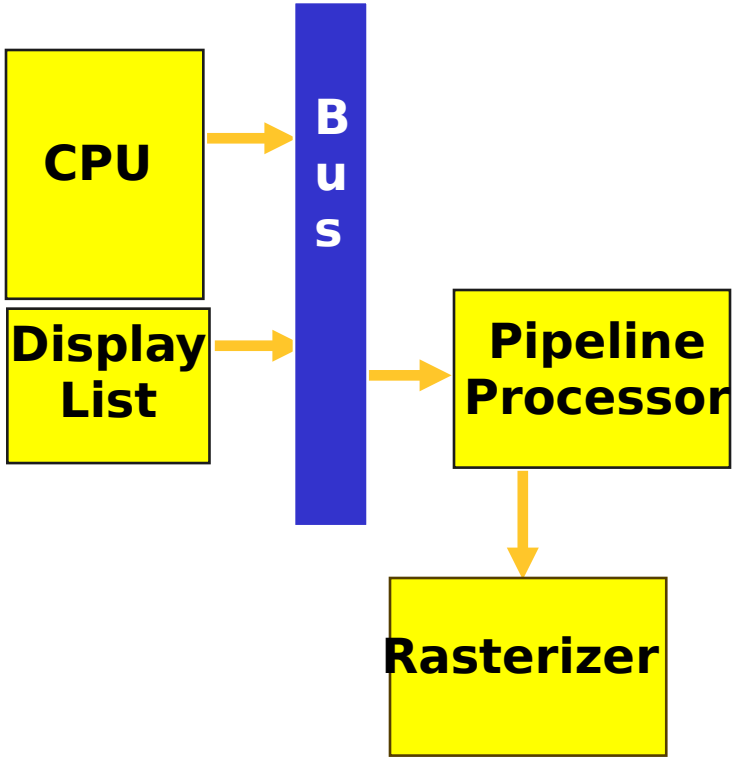
Texture Mapping

- "Stretch" an image onto a piece of geometry
- Image can be generated by a program or scanned in
- Very useful for realistic scene generation

Pipeline Processor

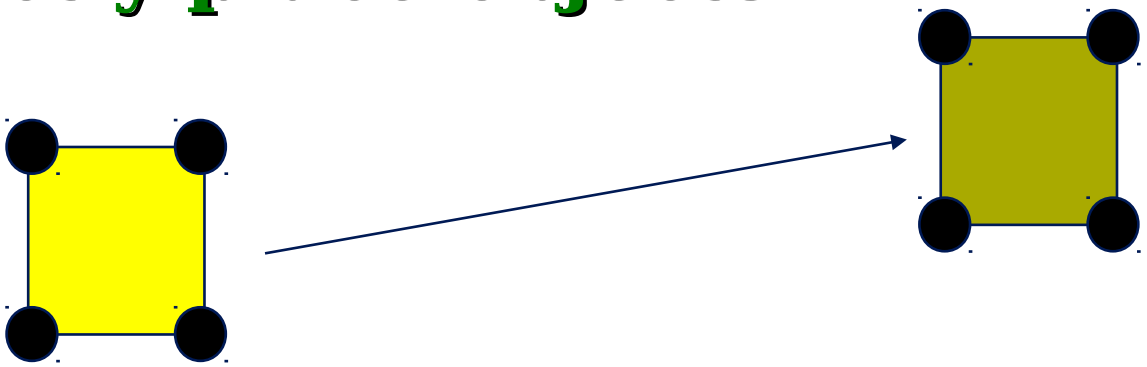
- Coordinates enter in world (application) coordinate space
- Coordinates leave in screen (pixel) coordinate space
- Another great place for custom electronics

The Pipeline Processor

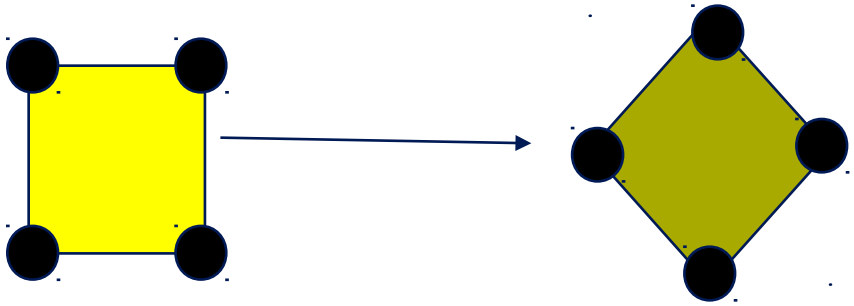


Pipeline Processor: Transformations

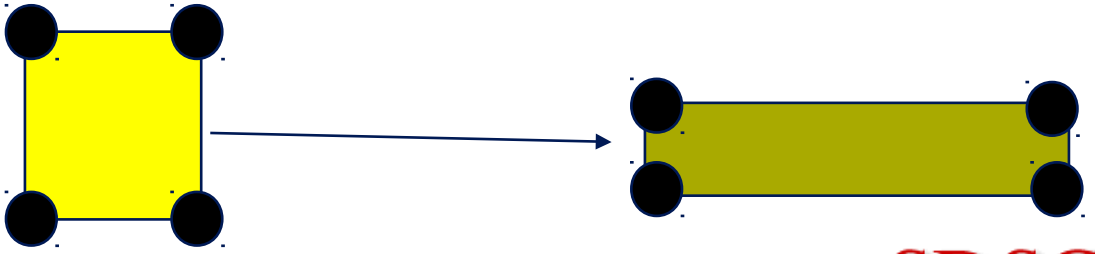
- **Used to correctly place objects in the scene**
- **Translation**



- **Rotation**



- **Scaling**

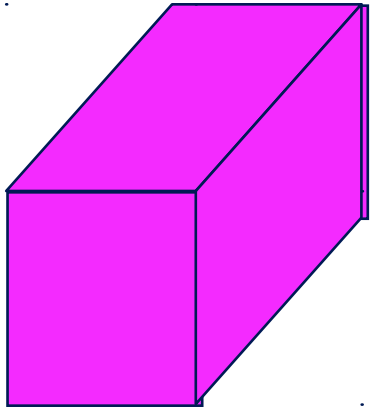


Pipeline Processor: Projection

- **Turn 3D coordinates into 2D**

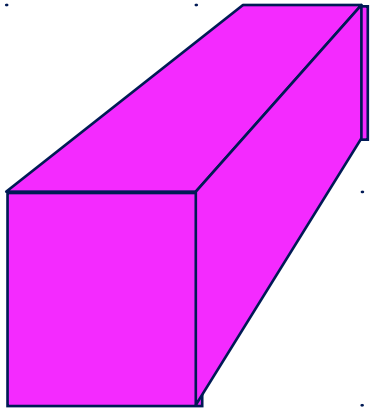
Parallel projection

Parallel lines remain parallel

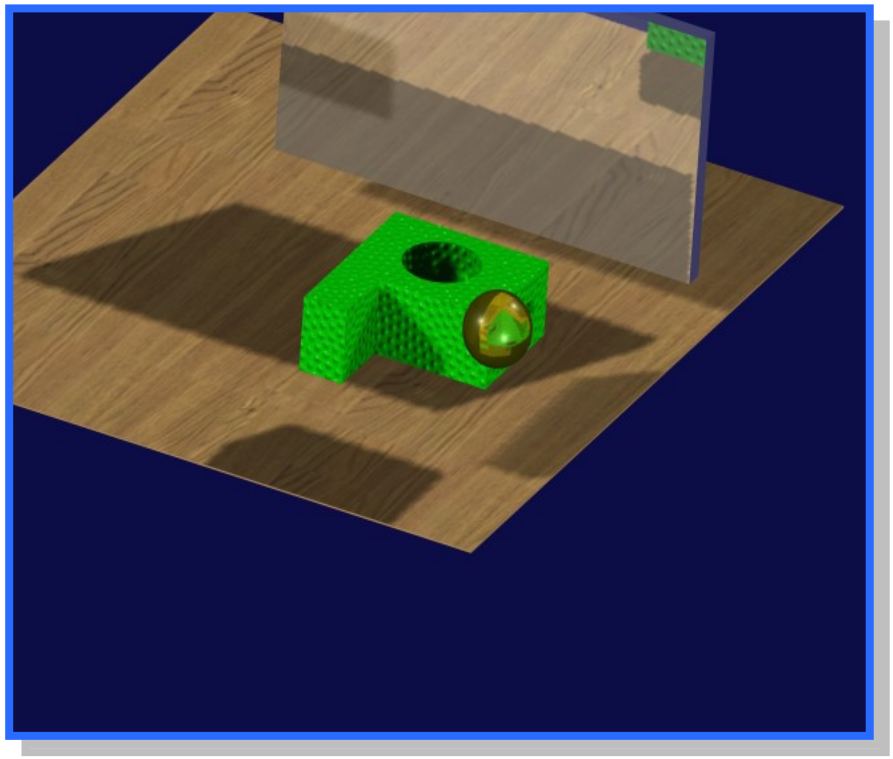


Perspective projection

Some parallel lines appear to converge

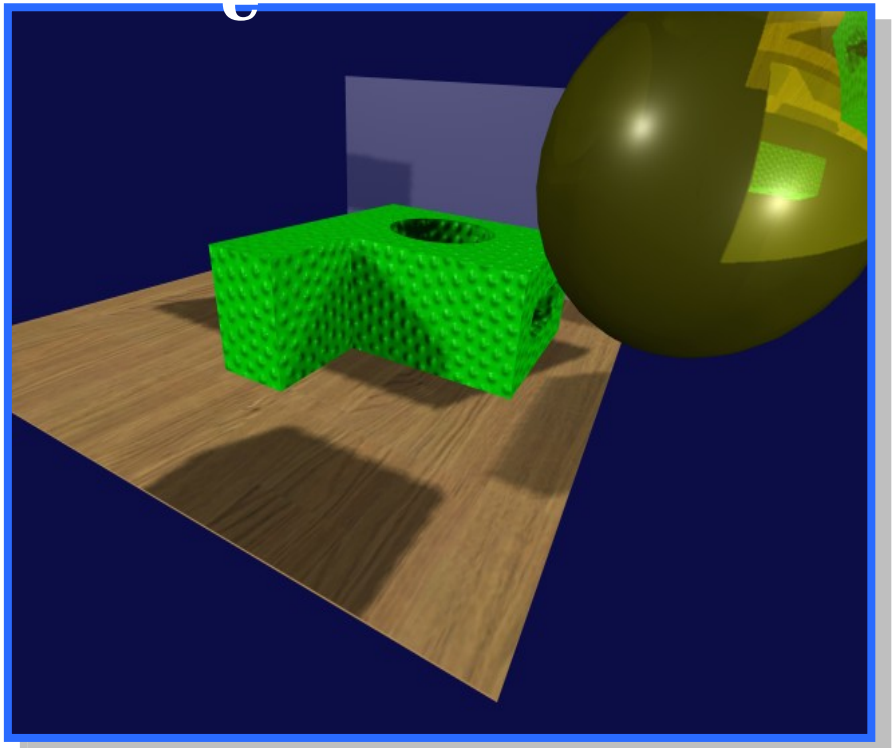


Pipeline Processor: Projection

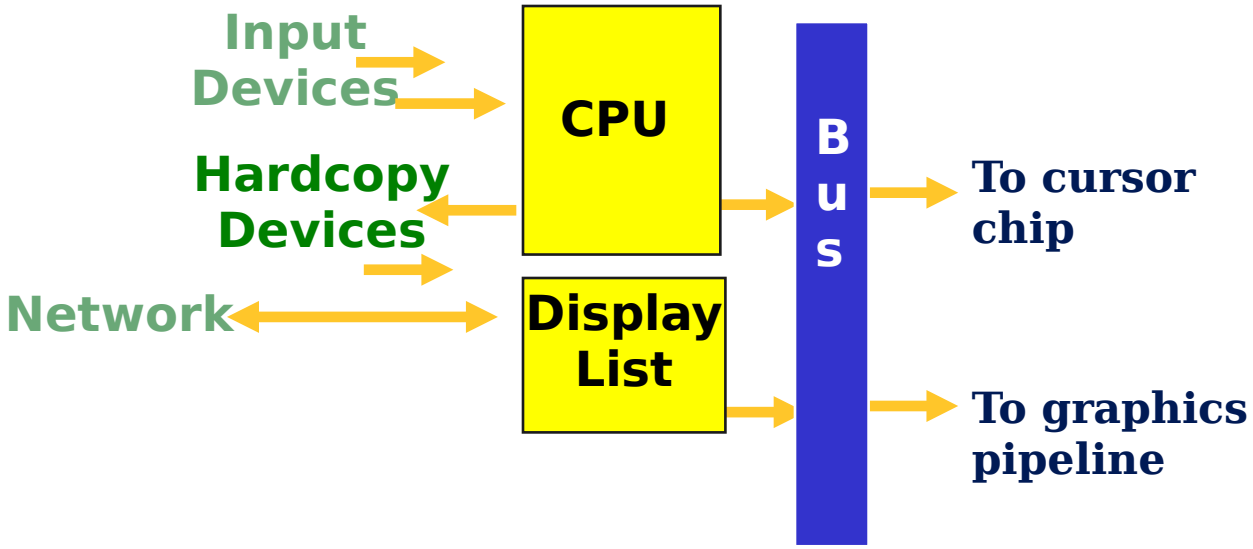


Parallel

Perspective



The CPU


Input Devices
Hardcopy Devices
Network
CPU
Display List
B u s
To cursor chip
To graphics pipeline

Input Devices: General Categories

- Text input
- Choice input
- Value input
- Coordinate input
  - 2D coordinates
  - 3D coordinates

2D Coordinate Input

- Mouse
- Joystick
- Trackball
- Digitizing pen
- Touchpad
- Touchscreen

3D Coordinate Input

- 3D joystick
- Spaceball
- Linkage
- 3D Trackers
- Glove

Graphics Hardcopy Devices

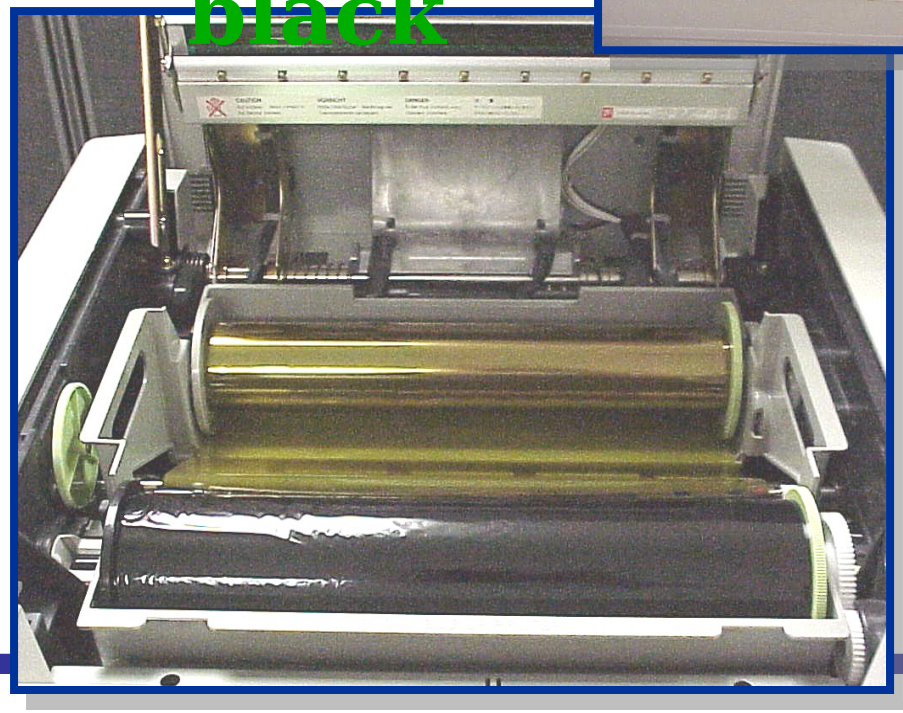
- Color paper plotters
- Film recorders
- Video
- Solid

Color Paper Plotting

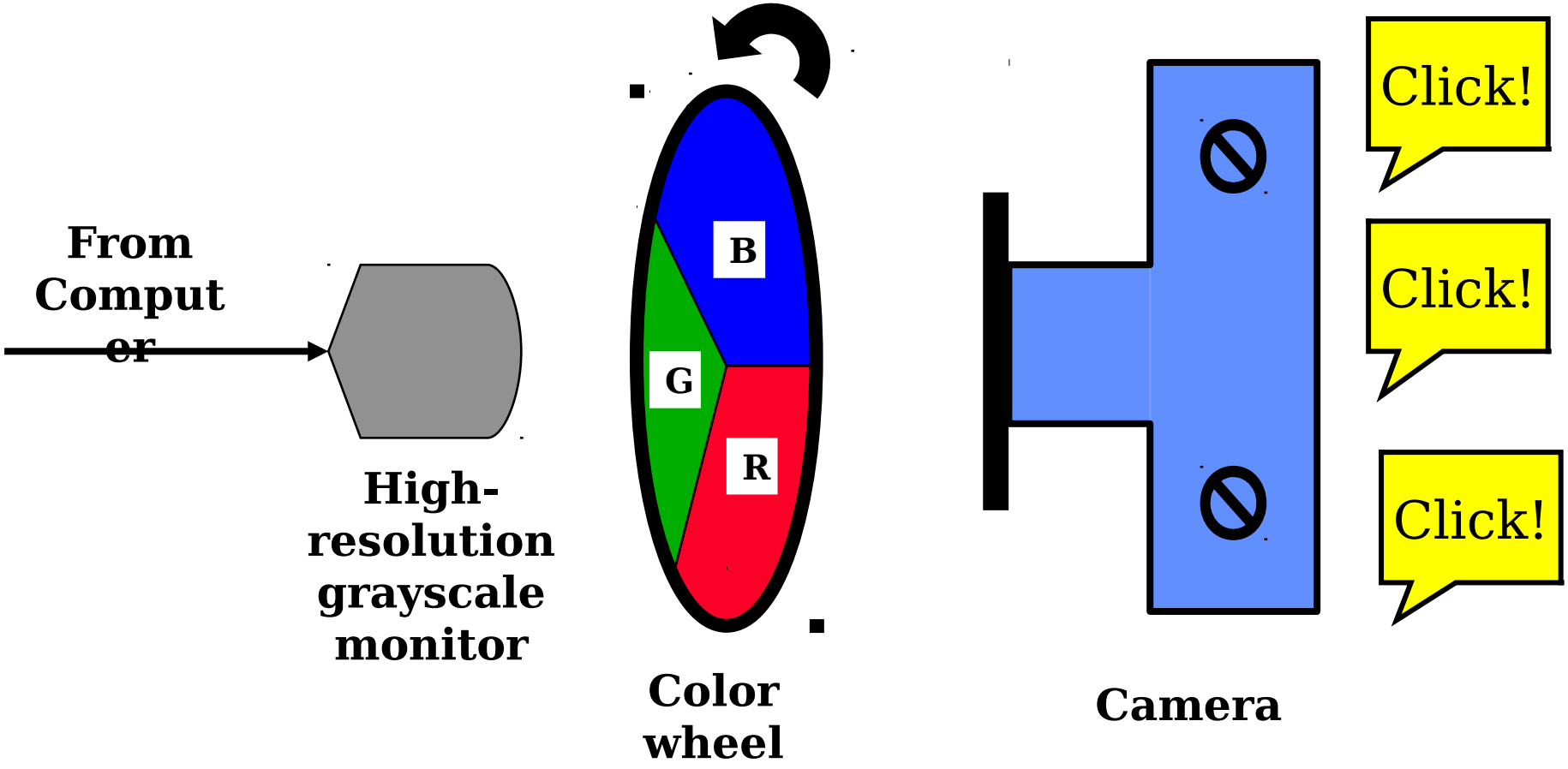
- Uses *subtractive colors*
- Cyan, magenta, yellow, black

Toner

Sheets



Digital Film Recording



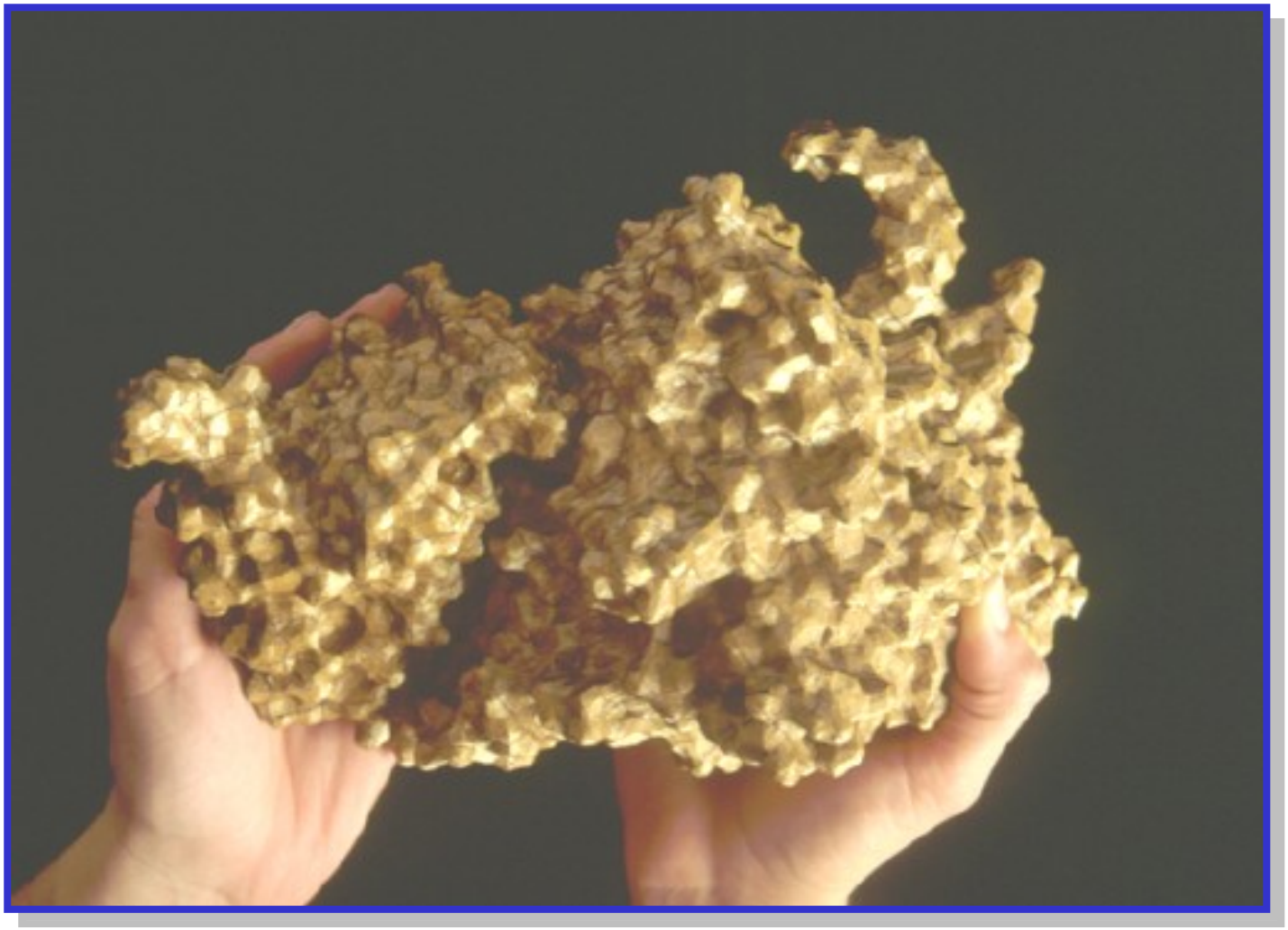
The Limitations of using NTSC Video

- Cannot display saturated colors well
- Expect an effective resolution of (at best) ~640x480
- Do not use single-pixel thick lines
- Stay away from the edges of the screen
- Some colors have better video resolution than others

NTSC Cycles of Encoding per Scanline

What:	Cycles/Scanline:
Intensity	267
Orange-Blue	96
Purple-Green	35

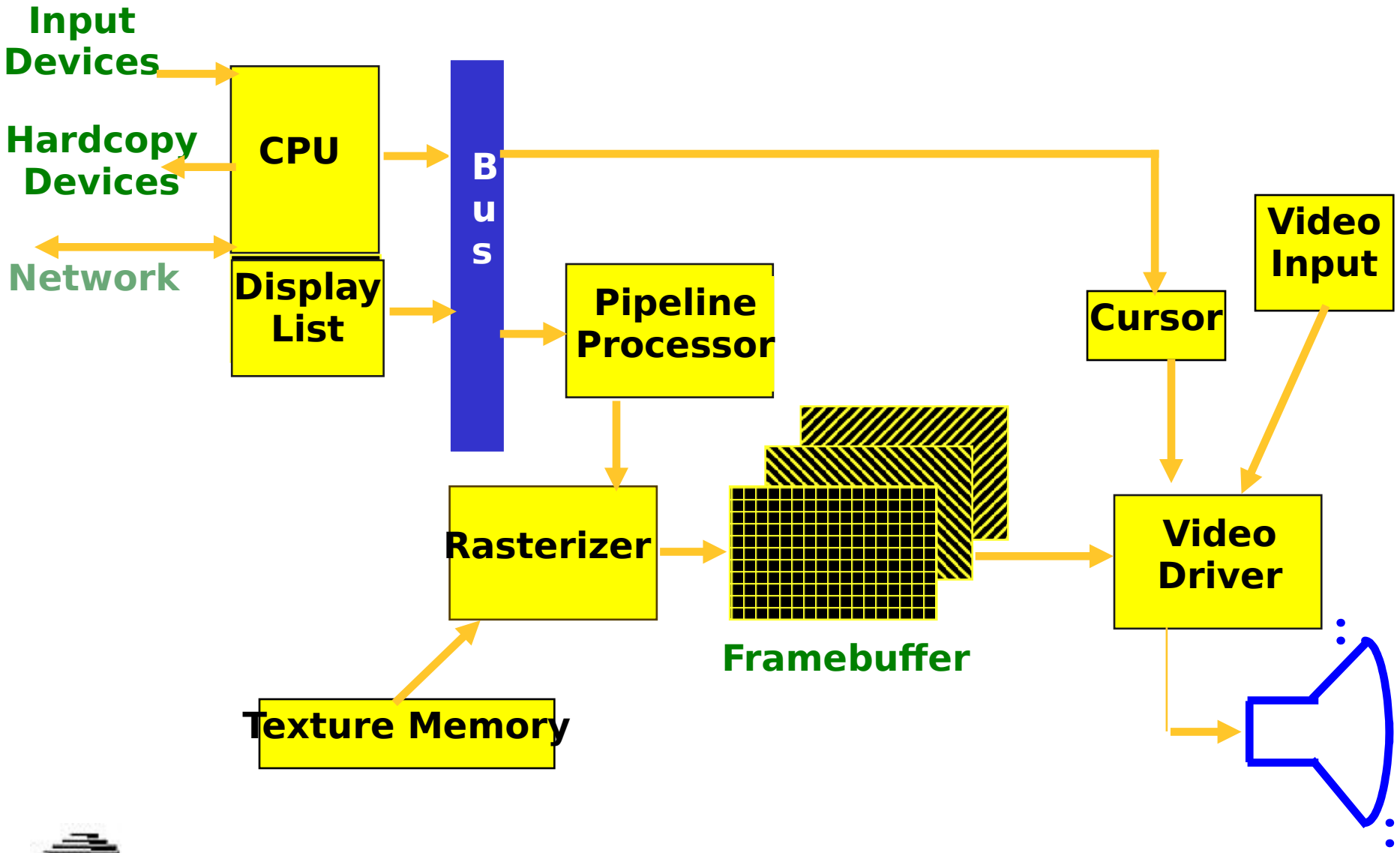
Solid Hardcopy



UCSD

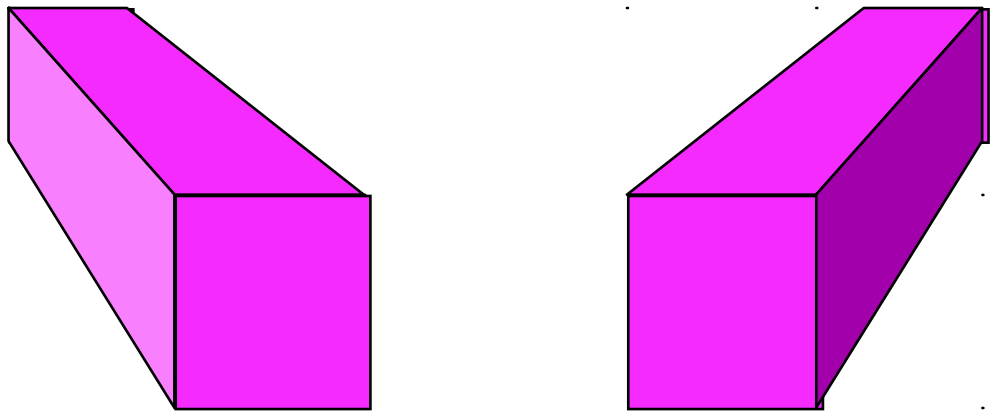
UCSD

All Together, Now!

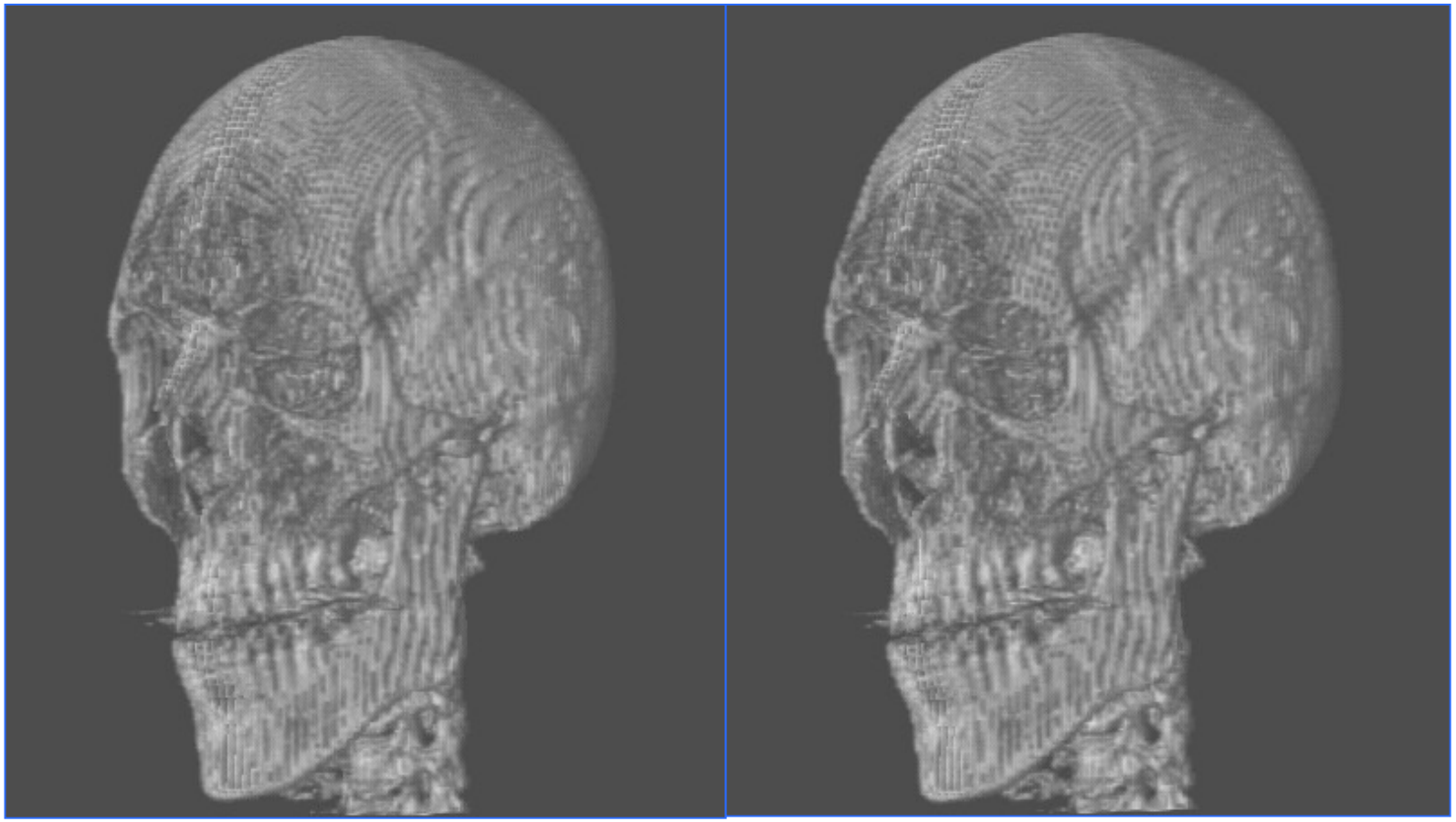


Stereographics

- Simultaneously display both left and right eye views



Stereographics



Left Eye View

Right Eye View

If You are Interested in Learning More:

Hardware will be discussed in more detail in the *Introduction to Computer Graphics* course on Monday, 11:15 - 12:00

UCSD SDSC

If You are Interested in Learning More:

Physical model hardcopy will be discussed in more detail in the

3D Hardcopy: Converting Virtual Reality to Physical

If You are Interested in Hardware, Remember:

The Exhibition closes at 5:00 on Thursday !!

Have fun this week, and Thanks for Coming!

Computer Graphics Hardware

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